United States Department of Agriculture

CHARACTERISTICS OF AGRICULTURAL SUPPLY AND DEMAND CURVES

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Summary of address before Section K of the American Association for Advancement of Science, in a joint program with the Econometric Society, Syracuse, N. Y., June 22, 1932

This paper attempts to bring together a number of studies, made by the writer during the past three or four years, which have been of practical use in anticipating changes in prices, marketings, and subsequent farm production. They are an outgrowth of the price analysis work sponsored by the Bureau of Agricultural Economics in its attempts to supply farmers with outlook information relative to prospective changes in supply and demand conditions.

The topics covered in this paper are:

(1) A simple illustration of an approach to the instantaneous supply and demand curves for commodities of fixed annual supply. The supply curves dealt with here are the current-supply curves representing supplies offered from a total fixed available quantity on hand.

(2) Relations between producer, dealer and total demand curves and two views of price determination.

(3) Shifts in demand curves, that involve changes in slope (of elasticity) and changes in level due to the value of money, population growth, etc.

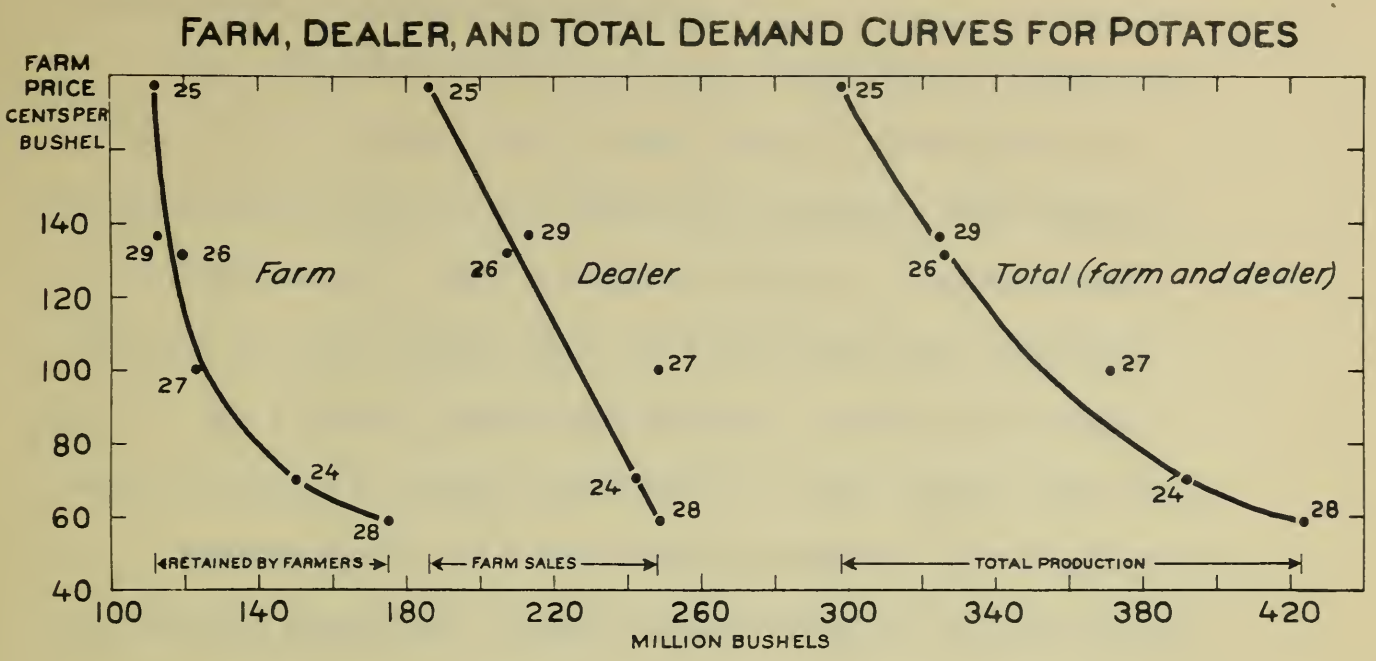
(4) Comparison of agricultural with nonagricultural demand curves.

(5) Subsequent-supply curves which show the effect of current prices on supplies of the following season or seasons.

The method of analysis used in this paper is the simplified graphic approach to multiple curvilinear correlation described by the writer in the Journal of the American Statistical Association in December 1929 and December 1930. That method has the advantage of allowing the data rather than the investigator's arbitrary technic to determine the nature of the functions involved. No assumptions (except that of additive relationships) were made and no set of preferred types of functions fitted. The results are shown in graphic form since, for practical purposes, no mathematical expression is necessary. If mathematical expressions are desired, they can be derived for the functions as developed graphically.

1. Farmer, dealer and total demand curves.

Figure 1, upper section, contains suggestions of the nature of the farmers' reservation-demand schedule, the dealers'-demand schedule, and the total national-demand schedule for potatoes, each schedule expressed in terms of prices at the farm. The dealer-demand schedule is suggestive of the consumer-demand schedule that would be expressed in terms of retail prices and quantities actually consumed each year. While the dealer-demand curve is drawn here as linear, it might turn out to be otherwise in analyses of more observations. The total-demand curve is here derived from production and price data. It has been argued that each observation in this type of scatter (production vs. price) may represent the intersection of an instantaneous demand and a supply curve, the shifting of the points of intersection being due to changes in the costs of production. But it will appear from a later illustration (Fig. 8) that the supply-price for this period remained unchanged.



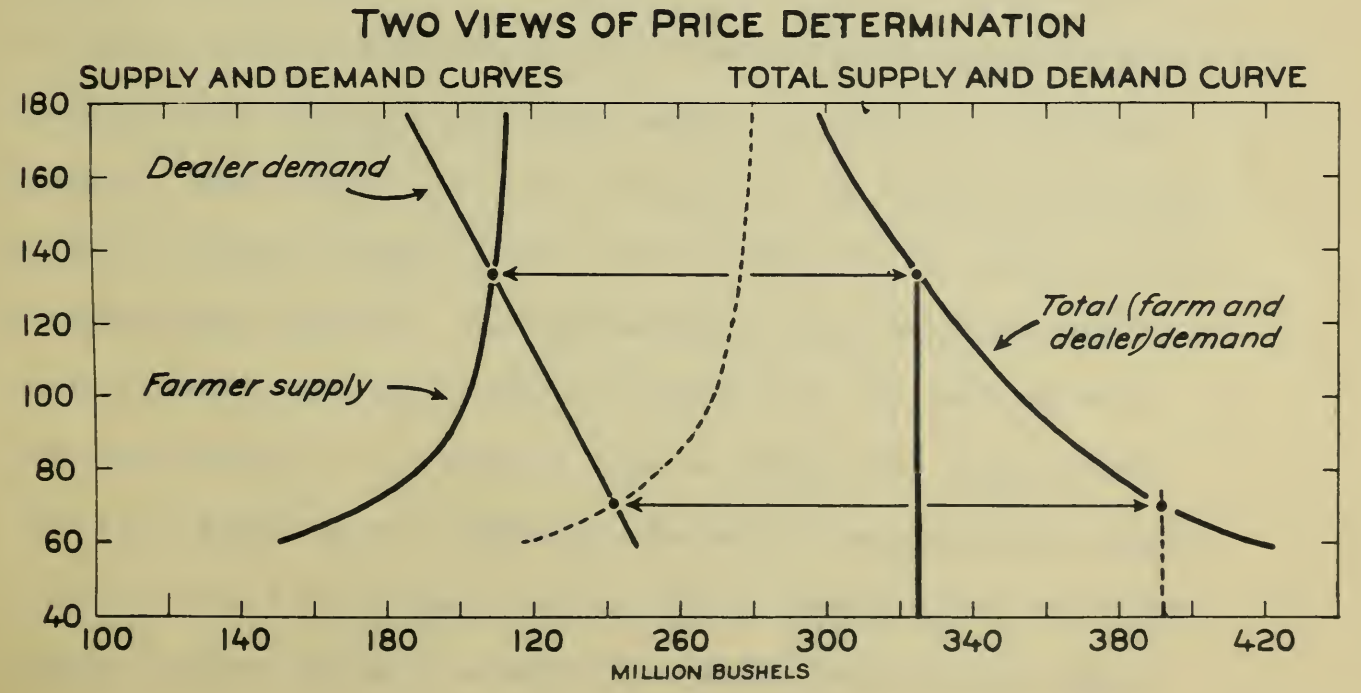


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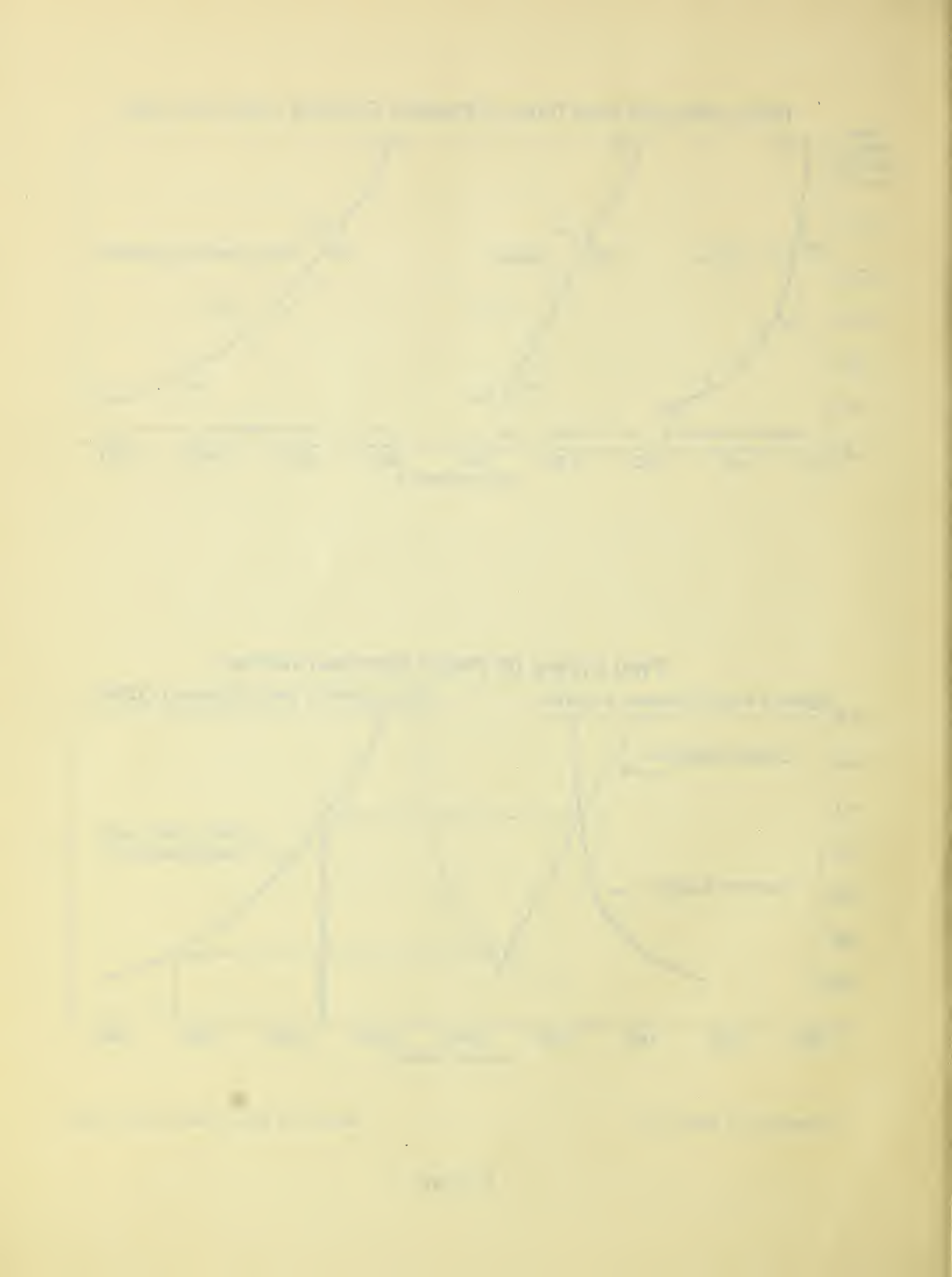
FIGURE 1



2. Two views of price determination.

The common way of viewing price determination statistically in the case of an annual crop is that price is determined by a production-price curve (here suggested as actually representing a total demand curve). Thus a crop of 325,000,000 bushels would intersect the total demand curve at $1.35 (see lower section of fig. 1) and a crop of 392,000,000 bushels, a price of 70 cents, given no changes in demand conditions or in the general price level.

Another view, that price may be determined by the intersection of a current demand and a current supply curve may be developed by utilizing the farmers'-demand or reservation schedule. The latter indicates the quantities retained or utilized for the several purposes on the farm (food, feed, seed) for different price conditions. Given a total production, it is possible to deduct the quantities in the reservation schedule to obtain the different quantities that farmers would release to the local dealers or markets at different places. Such a supply curve (the obverse of the farmers' reservation curve) is shown in Figure 1 for a crop of 325,000,000 bushels (marked "farmer supply curve"). The intersection of this schedule with the dealer demand curve (as developed in Section 1) is identical with the intersection of the vertical line at 325,000,000 bushels with the total demand curve. Similarly, deducting the reservation demand schedule from a total supply of 392,000,000 bushels gives the farmer supply schedule shown in a dotted line which intersects the dealer curve at 70 cents as the vertical line of total supply at 392,000,000 bushels intersects the total demand curve at the same price level.

It should be possible to adapt this illustration for a simple commodity to other commodities of more complex markets, to derive the so-called instantaneous supply and demand schedules involved in price determinations.

3. Shifts in demand curves.

Two types of changes in demand curves are generally recognized, one representing a change in slope, the other a change in level due to changes in demand conditions or changes in the value of money as shown by the rise and fall of the general commodity price level.

In Figure 2 are shown the results of an analysis of potato prices (December 1) related to total production, wholesale food prices in general and "time". The data cover five periods, each of which embraces the duration of a major economic cycle. The relation of production to price apparently did not alter materially during the first four periods covering the years 1878-1915. A marked change toward greater inelasticity occurred after 1920.

In so far as changes in commodity prices in general, as here represented by food prices, were responsible for changes in the level of the production price curve it appears that in two of the periods (1 and 5) the effect of a given change in food prices was twice as great as in the other three periods. Similarly the rate of vertical or diagonal shifting due to population growth and other factors was not uniform, being progressively more rapid in the first three periods 1878-1908, with apparently no further growth during the last two periods. This undoubtedly represents a declining per-capita demand in recent years. The more rapid growth during 1896-1908 may be related to the more rapid population growth of that period contrasted with that of the other periods.

PRODUCTION AND PRICE RELATIONS FOR POTATOES: CHANGES IN SLOPE AND LEVEL

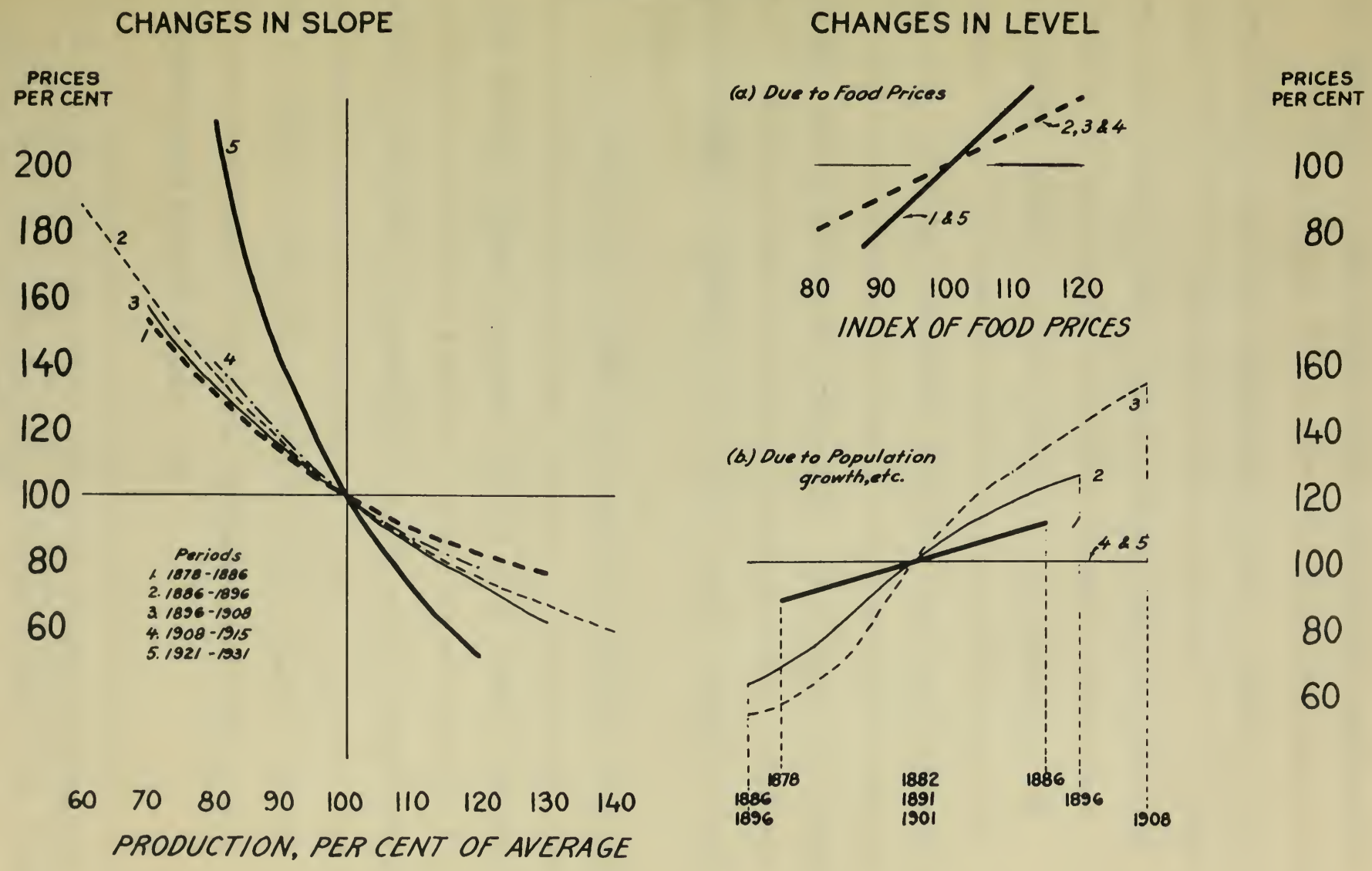


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FIGURE 2

4. Comparison of agricultural with nonagricultural demand curves.

Price investigators have shown that while the relation between production and price for agricultural products is negative, the comparable relation for industrial products is positive. H. L. Moore was led to theorize about a positive demand curve for industrial products, but had he used the multiple instead of simple gross correlation technic his results might have been otherwise. An examination of the relation of production and price for pig iron and steel, following a procedure similar to that used in the analyses of agricultural prices, yields negative relations for the industrial products as well as for the agricultural. These results are obtained by the simple procedure of including in the analyses a factor representing changes in demand so as to reveal the net relation of supply to price.

In Figure 3, for example, are shown for the period 1908-1914 the net influences on meat animal prices of (1) production (2) industrial activity (changes in demand) and (3) other factors represented by "trend in residuals". A similar analysis for pig iron (see fig. 4) using (1) production (2) industrial activity and (3) "other factors" or "trend in residuals," yields similar results, a negative relation for the effect of supply and a positive one for changes in demand. The trend in residuals in this case is downward, in contrast with an upward trend for meat animals. 1/

1/ For a criticism of the use of "residuals" instead of appropriate known variables, see L.H.Bean and G.B.Thorne on The Use of "Trends in Residuals" in Constructing Demand Curves, Journal of the American Statistical Association, March 1932.

Relation of Production and Demand To Prices of Meat Animals, 1908-1914

100 = 1908-1914 AVERAGE

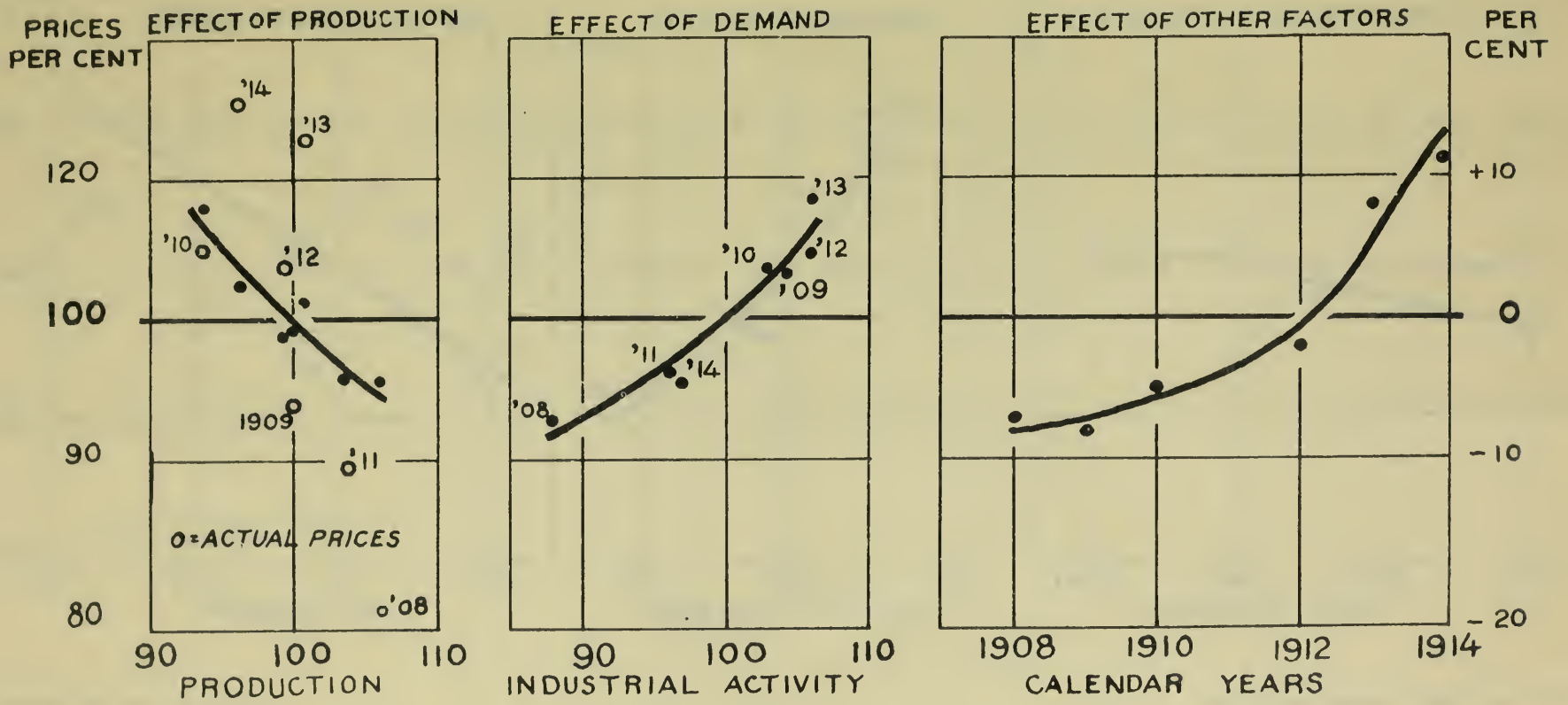

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FIGURE 3

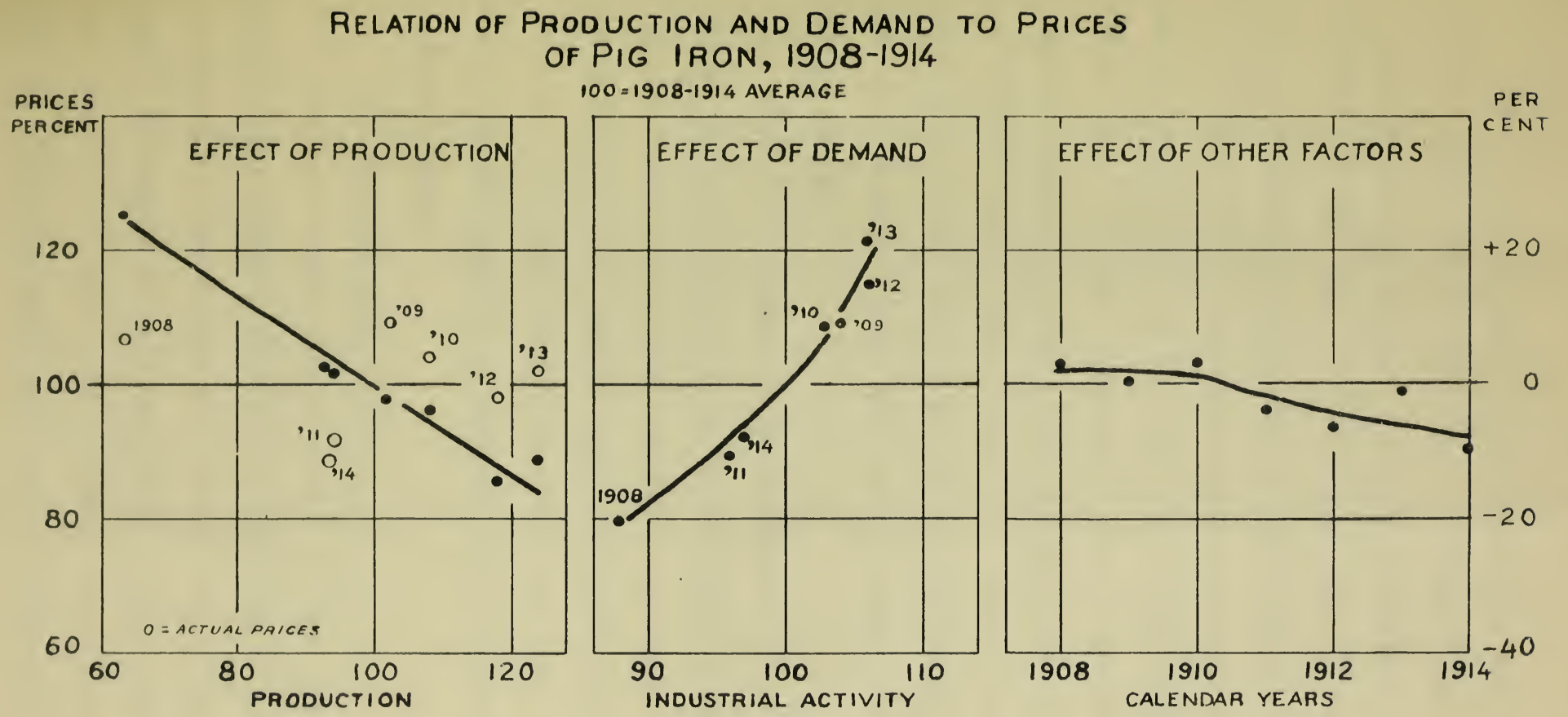

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FIGURE 4

These relationships are not accidental, for they appear also for the post-war period 1921-1931. In Figure 5 are given the results of analyses for meat animals, pig iron, and steel, for two periods 1908-1914 and 1921-1931, showing in each case the influences of production, industrial activity and "other factors". In each case, the production-price relation is negative; more elastic for meat animals than for pig iron and steel; more elastic for each in the post-war period than for the pre-war period; more pronounced influences of demand changes on prices of pig iron and steel than on prices of meat animals; upward trends in residuals for meat animals, downward trends for pig iron, both in the pre-war and post-war period, while steel shows an upward trend only for the post-war period. 1/ (See footnote on page 5)

These results point to the conclusion that the basic relations between supply and price are of the same type in agricultural and industrial products, but that industrial production is so much more quickly responsive to current changes in demand that there is a very high gross correlation between production and price, but if properly analyzed the net relation is negative, as is to be expected.

5. Supply curves.

(a) Current-supply curves.

The term "current-supply curves" is here applied to the producers' supply schedule which may be developed to cover the sales or marketings of any "instant" or period, a day, week, month or season. An example of a current-supply schedule for a season for a fixed quantity of a crop available for a given period was shown in Figure 1. That same supply curve can be developed by another method,

PRICES OF MEAT ANIMALS, PIG IRON, AND STEEL
RELATED TO SUPPLY AND DEMAND FACTORS

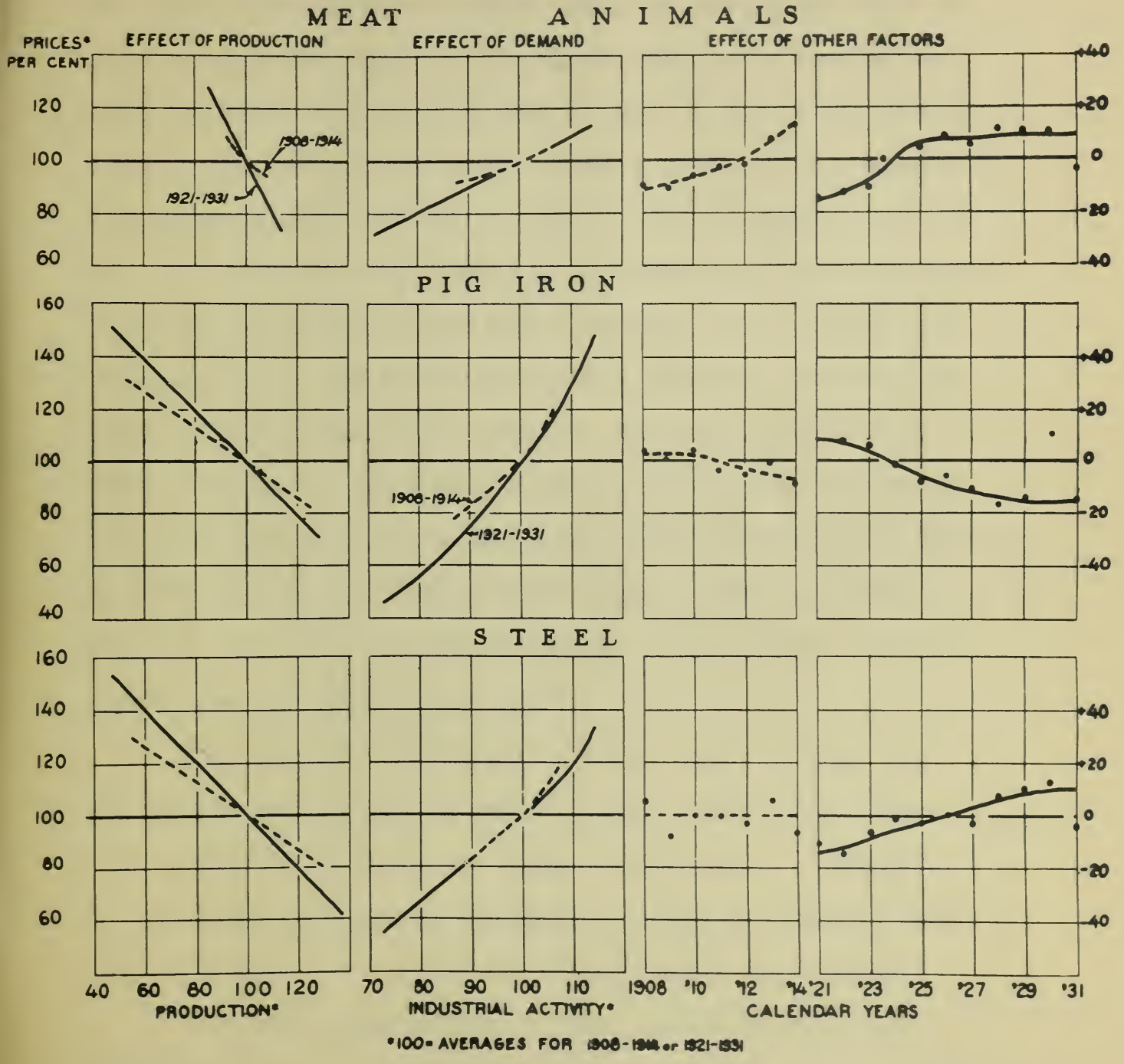

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FIGURE 5

applicable to a number of commodities where supplies released to dealers and markets differ from the total supply produced. Since the supply curve may be considered simply as showing the effect of price on marketing, that relation may be obtained by treating variations in marketings, say from year to year, as due to two factors, total supply available and price. With no changes in the producers' reservation demand, more will be sold as more is produced, so that the net relation between production and marketings should be linear. Deviations of sales from this linear relation, will be found to be related to price, and the latter relation therefore, indicates the nature of the current-supply schedule. This type of analysis is shown in Figure 6. For a crop of 350,000,000 bushels, associated with sales of 220,000,000 bushels, the supply schedule may be obtained by adding 220,000,000 bushels to the schedule shown in Section 2 of Figure 6. The curve is highly inelastic for high prices and very elastic for low prices (as in fig. 1).

This type of current-supply schedule may be obtained also for shorter periods than the entire season. Where total stocks still available are known, for example on January 1, or March 1, it is possible by a similar procedure to obtain the supply schedule for the balance of the season for which supplies are available.

The method shown in Figure 6 when applied to state data yields current-supply curves for different areas in contrast with the schedule for the United States as a whole. In Figure 7 the supply schedule for the United States (quantity expressed as percentages of average production) is contrasted with schedules similarly derived for several states, Iowa, Maine, Minnesota,

RELATION OF PRICE AND PRODUCTION TO YEARLY FARM SALES OF POTATOES IN 35 LATE STATES, 1924-1929

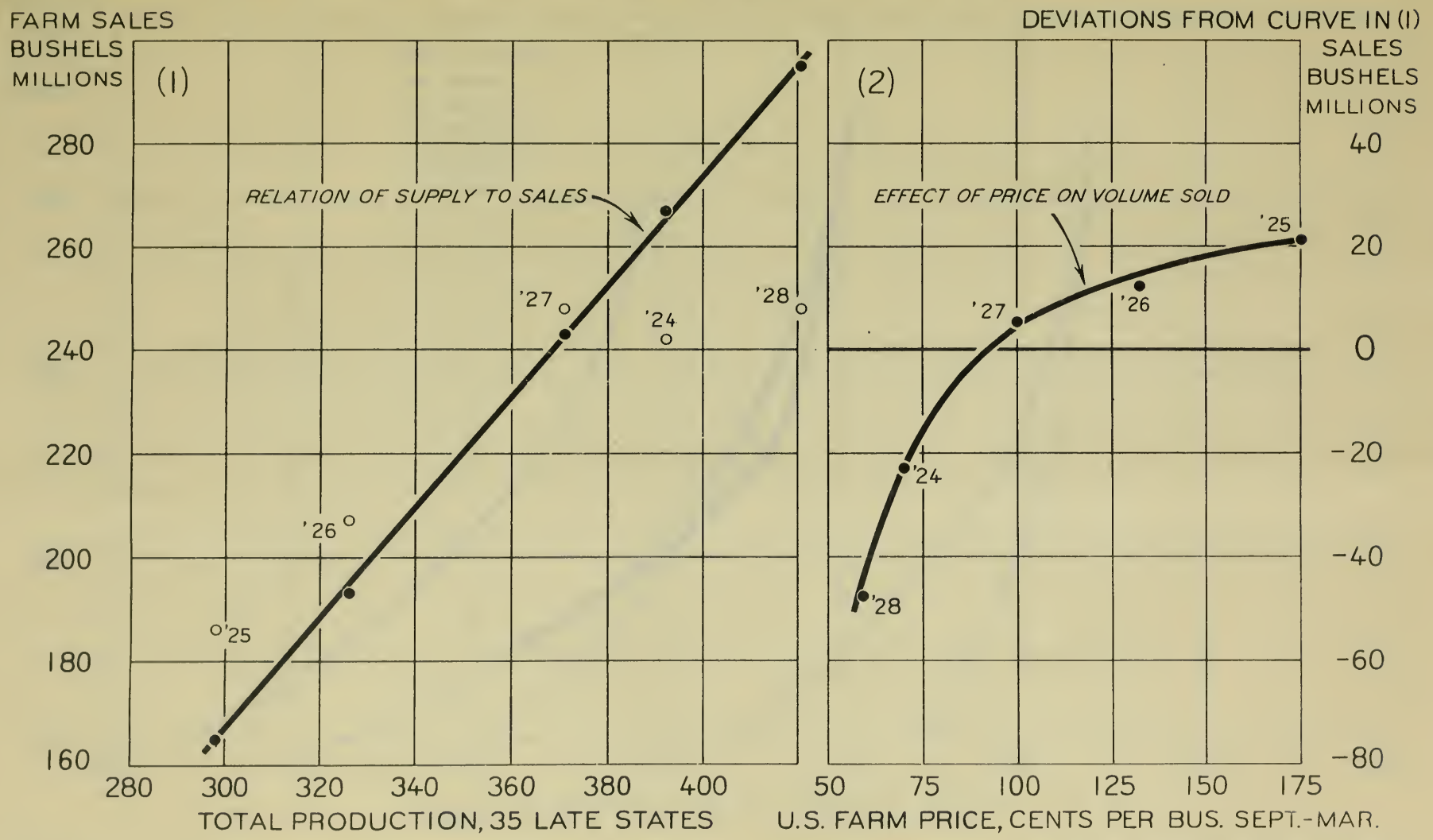

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FIGURE 6

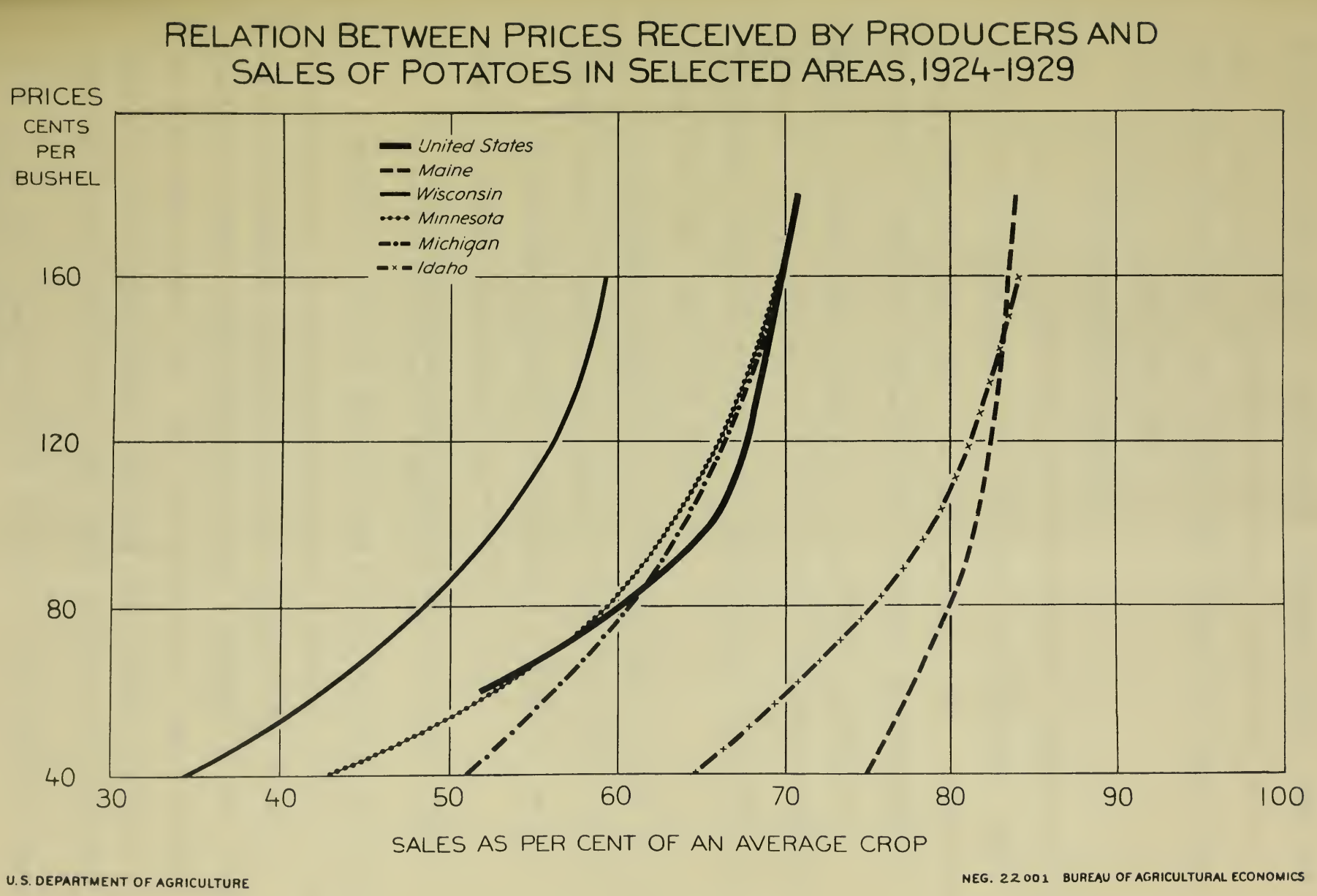
RELATION BETWEEN PRICES RECEIVED BY PRODUCERS AND SALES OF POTATOES IN SELECTED AREAS, 1924-1929
PRICES CENTS PER BUSHEL
United States
Maine
Wisconsin
Minnesota
Michigan
Idaho
160
120
80
40
30
40
50
60
70
80
90
100
SALES AS PER CENT OF AN AVERAGE CROP
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FIGURE 7

Michigan, and Wisconsin. In the highly commercial areas, Idaho and Maine, a much larger proportion of the crops is sold than in the more diversified areas. In all cases the schedules are more elastic for low prices than for high prices.

(b) Subsequent-supply curves.

This type of curve represents the producers' response to price in periods subsequent to the time when price was determined. Thus prices during the first part of a marketing period for a crop already produced may affect the subsequent rate or volume of marketing the balance of supply still on hand; or it may affect plantings and other factors that determine the next season's production (including expenditures for fertilizer and such cultivating and harvesting costs as may affect the size of the crop).

The following examples deal with the relation of price to subsequent changes in acreage and changes in livestock numbers (hogs).

The methods of analysis is illustrated in Figure 8 and the results of similar analysis are given in Figures 9-11. 1/

(1) Relation between prices received by growers and changes in the United States potato acreage.

Sections 1 and 2 of Figure 8 show the net relations of prices received one and two years preceding annual changes in potato acreage. Prices are adjusted for variations in the general level of prices received by farmers thus taking care of the "alternative crop" factor. The outstanding points are: the price of $1.00 per bushel (1927-28 general level of farm prices) associated with acreage stability; the inelasticity of response for prices higher than $1.20 and the marked

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1/ See also "The Farmers' Response to Price" in the Journal of Farm Economics, June 1929.

Relation Between Prices Received by Growers and Changes in the United States Potato Acreage

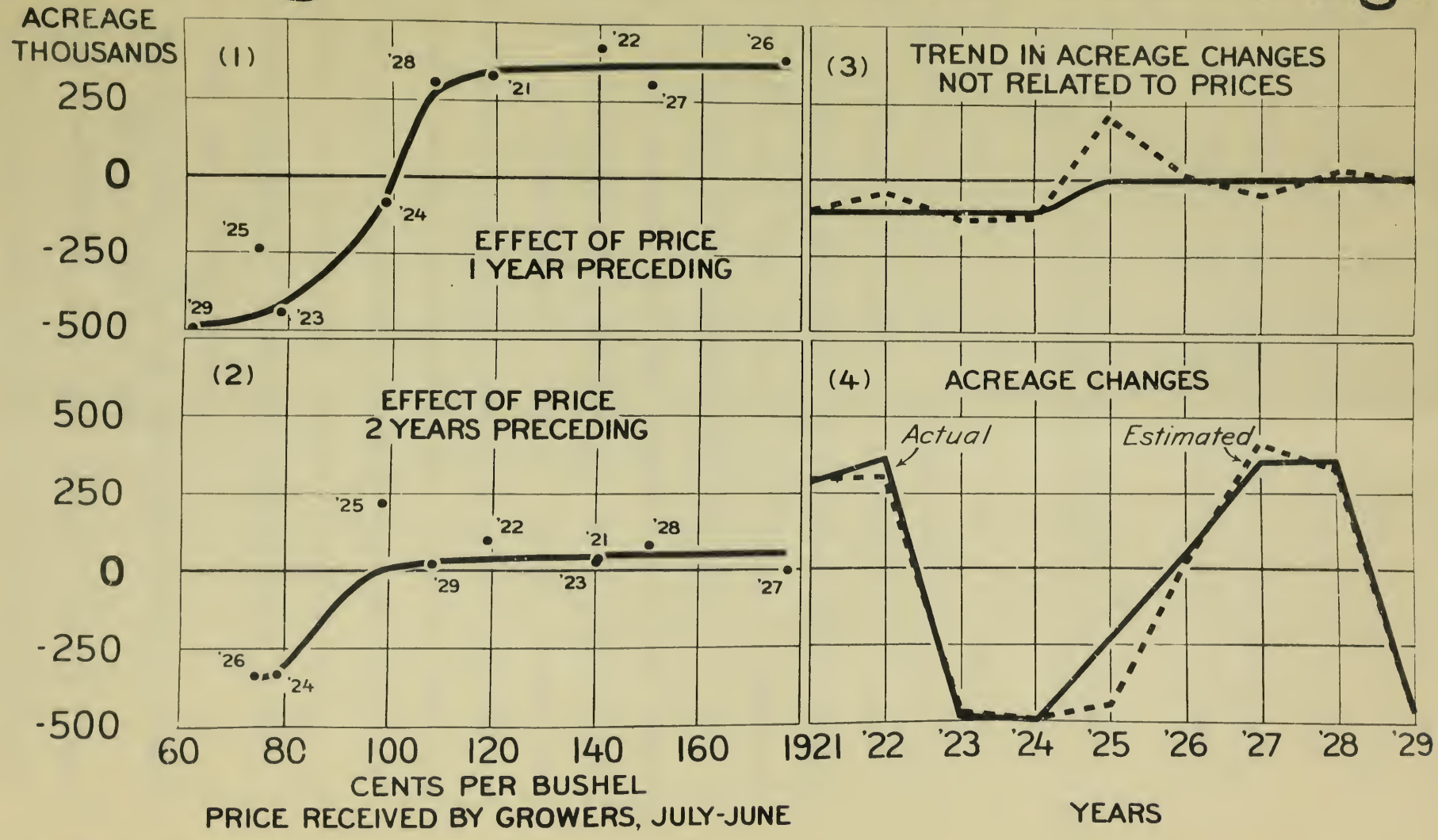

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FIGURE 8

elasticity for prices between $0.80 and $1.10; the greater influence of low prices two years preceding and the small influence of high prices two years preceding. Apparently the short-time "normal" price for this branch of agriculture for the post-war period was about $1.00 per bushel, for that price brought neither increase nor decrease in acreage.

(2) Relation between price received by producers and subsequent changes in potato acreage, United States, Michigan, New York and Idaho.

Figure 9 shows the relation of price one year preceding to acreage changes for several areas. Compared with a price of $1.00 for the United States, the acreage stability prices for New York, Michigan, and Idaho were respectively $1.11, $0.85 and $0.63 during the post-war period, varying inversely with distance to consuming centers, and directly with production costs per unit.

For direct comparability these schedules have been expressed in terms of percentages of the 1928 acreage, and in terms of percentages of the prices associated with "zero" acreage change. The outstanding points are the general similarity of the subsequent-supply schedule: the greater flexibility for commercial areas like Idaho and the apparent inelasticity for both very high prices and very low prices, which implies the presence of limiting factors to unusual acreage expansion or contraction, such as labor, credit, additional land, crop rotation systems, etc.

(3) Relation between price and subsequent changes in acreage, nine crops and number of hogs.

Figure 10 constructed in a manner similar to that of Figure 9 compares the subsequent-supply curves for nine crops and for hogs.

RELATION BETWEEN PRICE RECEIVED BY PRODUCERS AND SUBSEQUENT CHANGES IN POTATO ACREAGE, UNITED STATES, MICHIGAN, NEW YORK, AND IDAHO

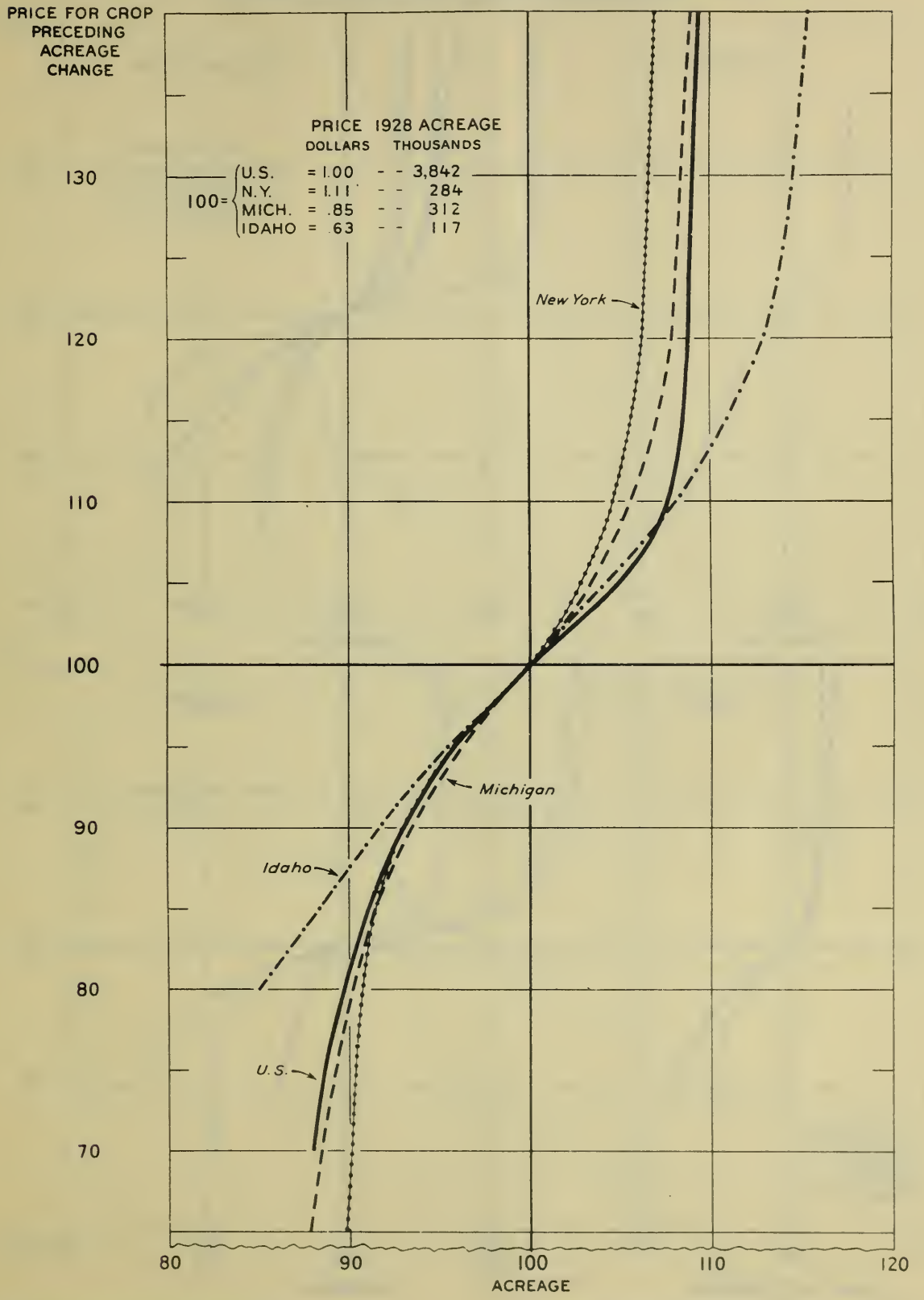

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FIGURE 9

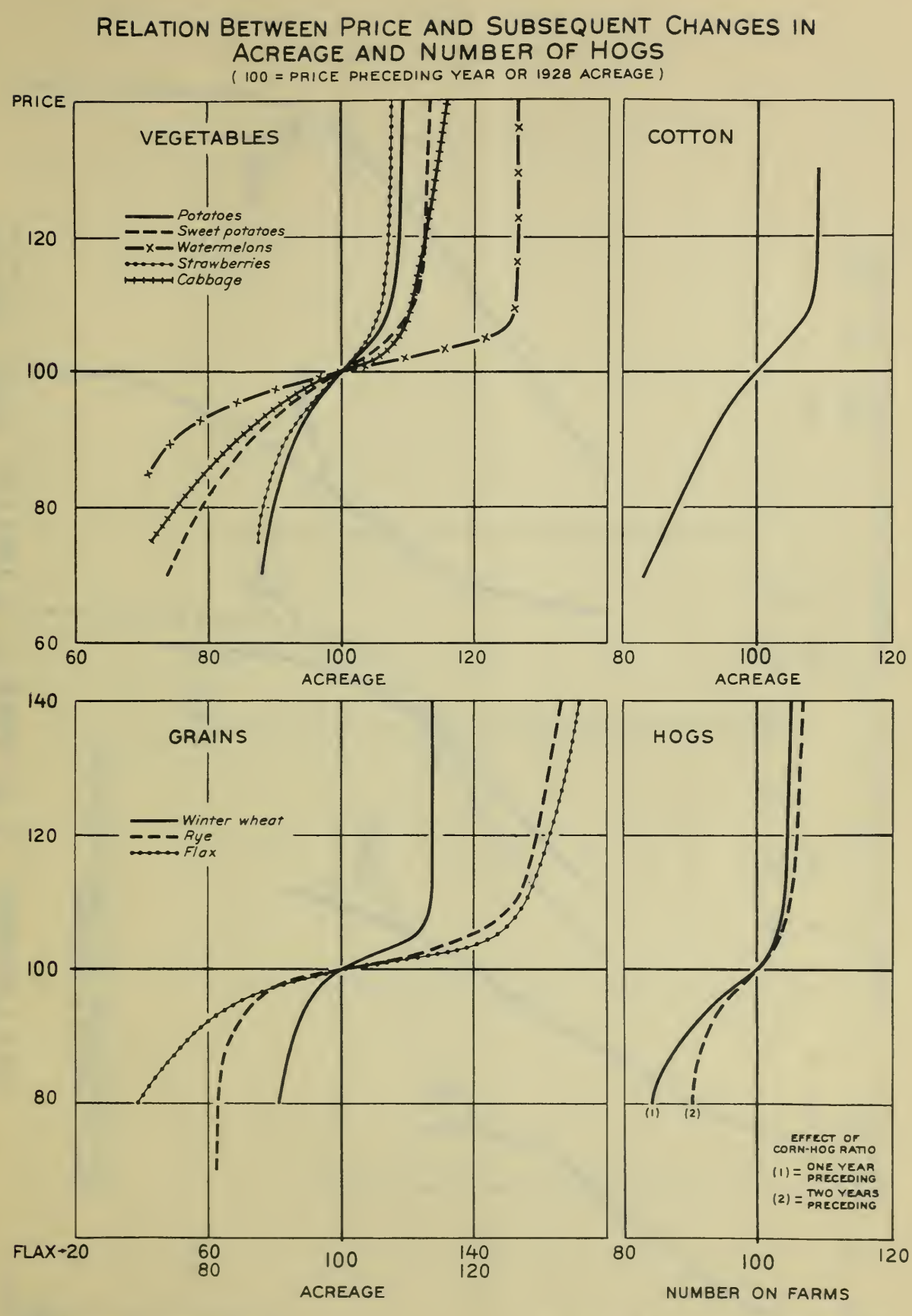
RELATION BETWEEN PRICE AND SUBSEQUENT CHANGES IN ACREAGE AND NUMBER OF HOGS
(100 = PRICE PRECEDING YEAR OR 1928 ACREAGE)
PRICE
VEGETABLES
Potatoes
Sweet potatoes
Watermelons
Strawberries
Cabbage
120
100
80
60
60
80
100
120
ACREAGE
COTTON
80
100
120
ACREAGE
140
GRAINS
Winter wheat
Rye
Flax
120
100
80
FLAX÷20
60
80
100
140
120
ACREAGE
HOGS
(1)
(2)
EFFECT OF CORN-HOG RATIO
(1) = ONE YEAR PRECEDING
(2) = TWO YEARS PRECEDING
80
100
120
NUMBER ON FARMS
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FIGURE 10

HOG-CORN RATIOS AND CHANGES IN HOG NUMBERS ON FARMS, U.S. AND 5 STATES, 1922-1932

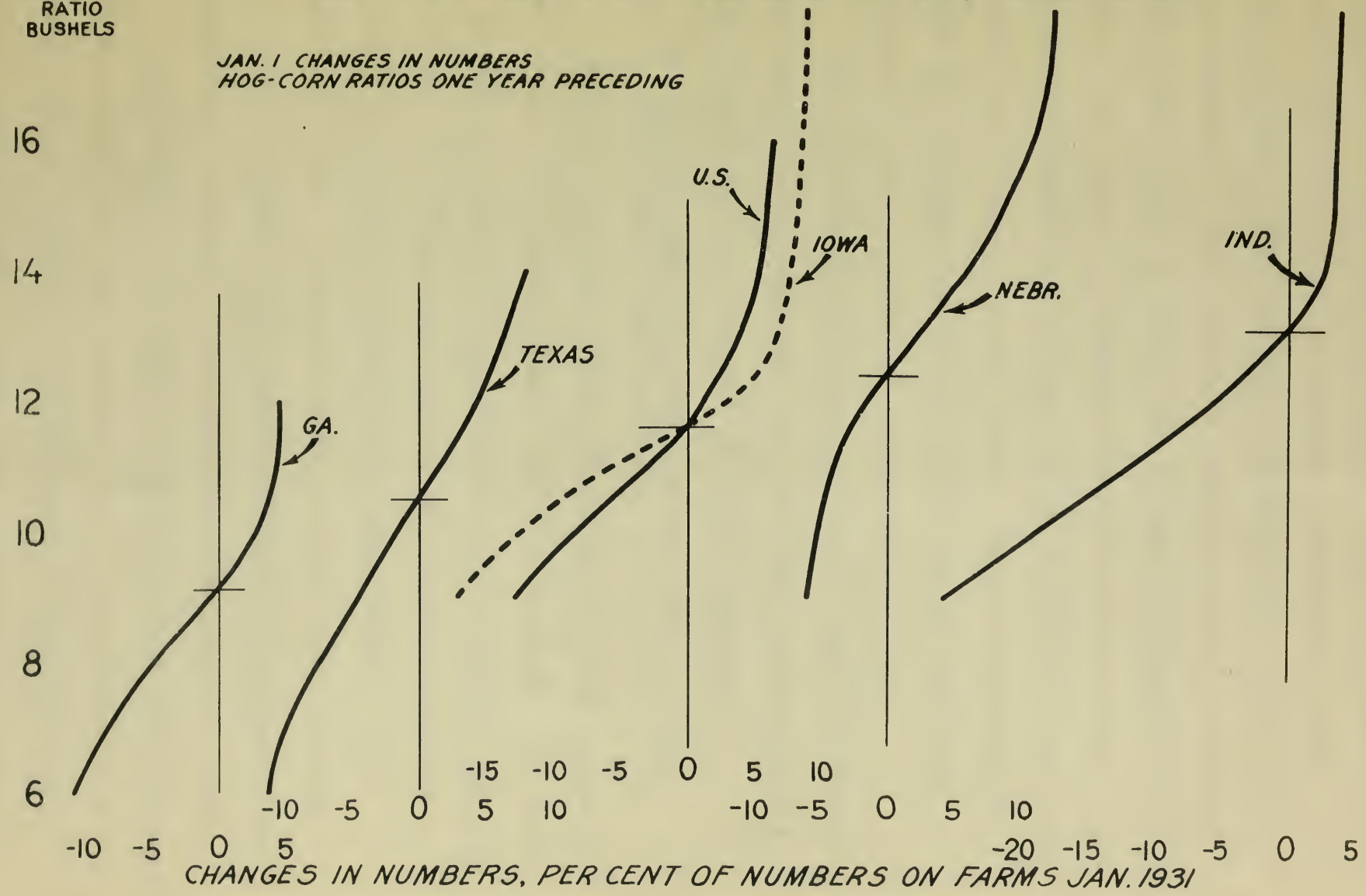

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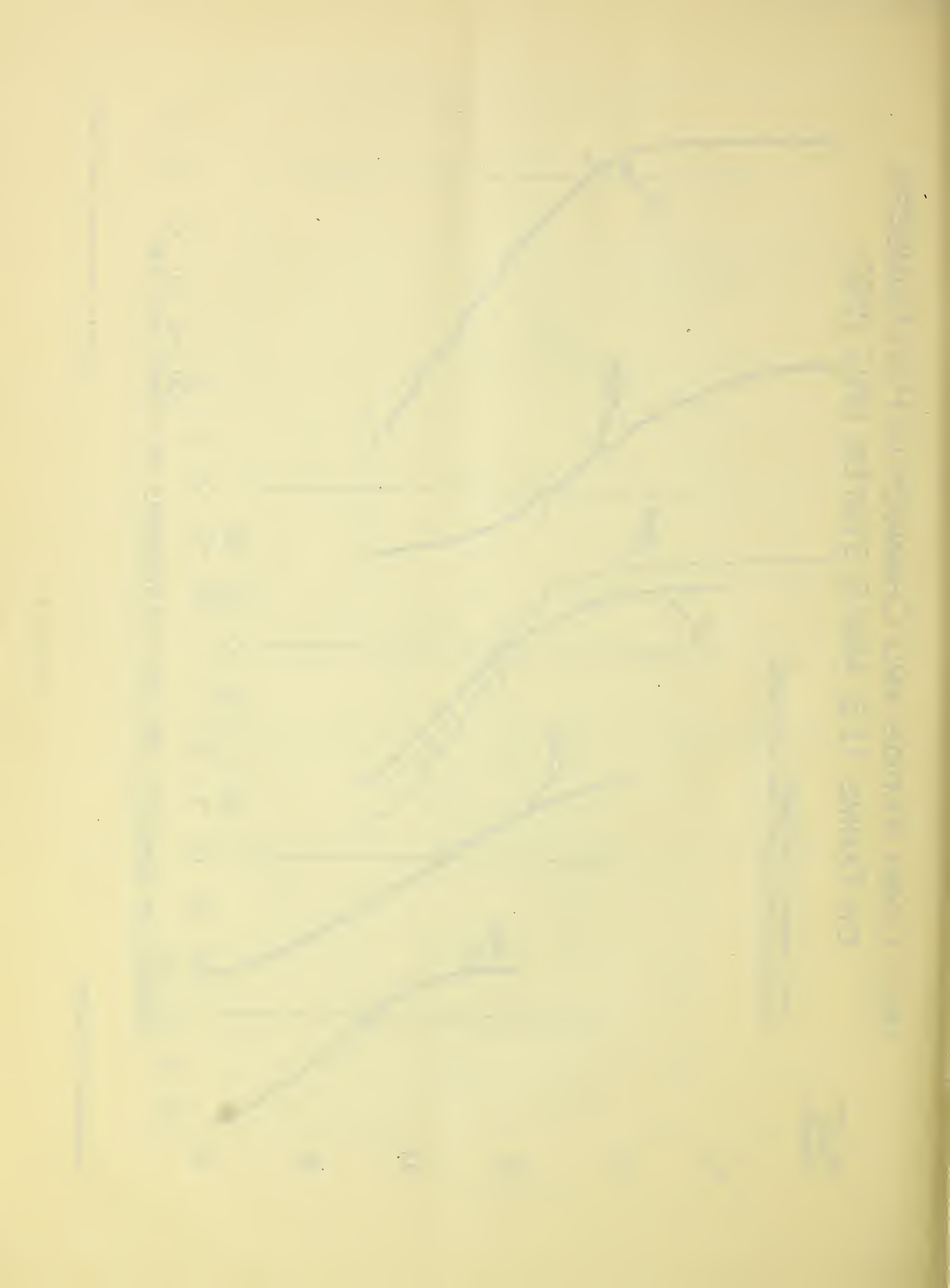
FIGURE 11



Except for the latter, the influences of prices two seasons earlier are not shown (for details of analyses, see Farmers' Response to Price in Journal of Farm Economics for June 1929). In the case of four commodities, prices instead of being adjusted to the 1927-28 level of farm prices in general were adjusted for changes in the prices of the specific alternative commodities (sweet potato prices adjusted for cotton price changes; and rye and flax for wheat price changes; hog for changes in corn prices, the latter representing either the alternative disposition of the corn crop as between feeding a cash sale, or the feed cost of producing hogs).

Note that the acreage scale for flax is double that for the other commodities and this shows flax to be the most elastic of the supply curves shown here, followed by rye and watermelons.

(4) Hog-corn ratios and changes in hog numbers on farms, United States and Five States.

Figure 11 shows for several regions supply curves similar to those shown in the right hand lower corner of Figure 10. The effect of the hog-corn ratios two years earlier are not included. The hog-corn ratios for calendar years were in this analysis related to changes in hog numbers on farms the following January 1. The analysis for Texas and Georgia included also the price of cotton as a factor in changes in hog numbers. Changes in hog numbers were expressed as percentages of the numbers on farms January 1, 1928.

Considerable differences are revealed here and their explanation involves differences in the characteristics of hog production in the several states. In Georgia a hog-corn ratio of only nine bushels tended to keep hog numbers constant while in Indiana it required a ratio of 13 bushels. For relatively low hog-corn ratios the supply

curves for Indiana and Iowa appear the most elastic, for Nebraska the least elastic. For relatively high hog-corn ratios the supply curves for Nebraska and Iowa appear the most elastic and for Indiana and Georgia the least elastic.

The lower hog-corn ratios for the Southern States probably result from corn prices being relatively high because distant from the Chicago and other midwestern corn markets, and because of lower quality and therefore lower priced hogs.

Note: While most of the curves shown in this paper have been tested out in practice and found useful in forecasting changes in supplies subsequent to the period covered by the analysis, they are all probably subject to considerable revision either because the basic data have since been revised or because the inclusion of additional observations may call for changes in the slope or shape of the curves. But these prospective revisions will not materially alter the broad characteristics of agricultural supply curves here presented.

For the method used in deriving the relationships shown in this study, see the following articles by L. H. Bean:

A Simplified Method of Graphic Curvilinear Correlation, Journal of the American Statistical Association, December 1929.

Application of a Simplified Method of Correlation to Problems in Acreage and Yield Variations, Journal of the American Statistical Association, December 1930.